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ISSUES IN PROGRAMMING INSTRUCTIONAL MATERIALS FOR TELEVISED PRESENTATION. STUDIES IN TELEVISED INSTRUCTION, REPORT 5.

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A SERIES OF EXPERIMENTS WAS CONDUCTED TO TEST THE EFFECTIVENESS OF TELEVISED INSTRUCTION. THIS STUDY, THE FIFTH IN A SERIES, EXAMINED SOME OF THE ISSUES INVOLVED IN PROGRAMING LEARNING SEQUENCES FOR TELEVISION. THE TOPICS REPORTED WERE--(1) BASIC OBJECTIVES AND FUNCTIONS OF PROGRAMED AUTOINSTRUCTION, (2) OBJECTIVES IN APPLYING PROGRAMING PROCEDURES TO TELEVISION, (3) PHYSICAL CHARACTERISTICS OF THE TELEVISION MEDIUM, (4) ROLE OF THE PROGRAM USED WITH INSTRUCTIONAL DEVICES, AND (5) PROGRAMING FOR TELEVISION. SPECIFIC PROCEDURES AND PROBLEMS IN PROGRAMING WERE DISCUSSED AND RELATED TO PRACTICAL EXPERIENCE GAINED IN STUDIES ON INITIAL ATTEMPTS TO PROGRAM FOR FIXED-PACE PRESENTATION. A CONCLUDING SECTION IS DEVOTED TO THE FUTURE ROLE OF PROGRAMED TELEVISION INSTRUCTION. RELATED REPORTS ARE ED 003 646 THROUGH ED 003 653. (JC)

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STUDIES IN
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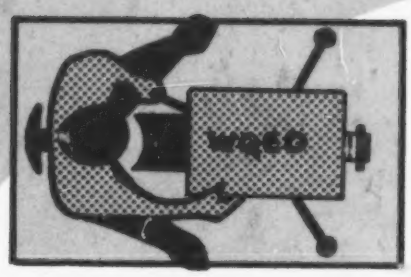

ISSUES IN PROGRAMMING INSTRUCTIONAL MATERIALS FOR TELEVISED PRESENTATION

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PITTSBURGH, PENNSYLVANIA

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STUDIES IN TELEVISED INSTRUCTION

Report Number 5

ISSUES IN PROGRAMMING INSTRUCTIONAL MATERIALS FOR TELEVISED PRESENTATION -- Studies in Televised Instruction, Report 5.

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and

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Metropolitan Pittsburgh Educational Television Stations
WQED-WQEX

and

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OVERVIEW

This is one of a series of reports on studies that use student responses to improve televised instruction. In these studies student response was used in three different ways. All three kinds of use shared the common objective of utilizing student responses to provide tangible, measurable indications of the adequacy of instructional procedures for attaining the educational goals of TV lessons.

1. USE OF STUDENT RESPONSE

...To Pre-test a TV Lesson

Student responses on an achievement test following a preview showing of a TV lesson were used as a basis for preparing a revised version of the lesson. Student performance on each test question indicated which points were fairly well learned and which points were not. This information provided useful feedback to the TV instructor, guiding him in the preparation of a more effective revision of his lesson.

2. USE OF STUDENT RESPONSE

...To Evaluate "Programming" Adequacy

...To Enhance Learning Effectiveness

"Programming" techniques derived from research on self-instructional devices were applied in the preparation of TV lessons. A primary purpose of these techniques was to facilitate correct responses by students. Procedures were designed to elicit active responding throughout the lesson. Students' ability to respond correctly provided evidence of how adequately the lesson sequences were programmed. Also, when students were encouraged to make frequent active responses to lessons programmed so they could respond correctly, the effectiveness of the lessons was significantly increased. Student responding was thus used first, to indicate the adequacy of lesson programming and second, to increase lesson effectiveness.

3. USE OF STUDENT RESPONSE

...To Evaluate Incentive Created by a TV Lesson

A TV lesson was designed to stimulate student follow-up activity. Students were encouraged to perform experiments at home that they had seen demonstrated on TV. Student responses in performing experiments at home on their own indicated the effectiveness of the TV lesson in providing an incentive for follow-up activity.

Much of the responsibility for attaining the instructional objectives of a TV lesson rests with TV teachers and producers. Student responses can be considered as the building blocks of the program. This means devising instructional procedures that will elicit appropriate responses, and judging these procedures as adequate only when students do, in fact, respond appropriately. This kind of careful and systematic attention to student responses should contribute strongly to the successful attainment of educational objectives.

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The report presented in this volume discusses the problems and issues involved in the dual use of student responses, i.e. to test programming adequacy and to enhance learning effectiveness.

INTRODUCTION

In this report the terms "program," "programming," and "programmed" are used in the special sense which they have acquired in the context of research on auto-instructional materials or, as they are otherwise known, teaching-machine programs (cf. 19 & 23). The most fundamental aspect of this usage is perhaps the emphasis on effective control of the learner's behavior (see below). Earlier reports in this series (7, 8, & 9) have described the initial application to television of programming principles and techniques derived from this research. The applicability of instructional procedures derived from the one medium to the other rests, it seems clear, on functional similarities between the two. In this case, it rests on the capability of the television medium to fulfill essential functions that characterize programmed instruction with teaching machines.

Reviews of teaching-machine research (3 & 17) have analyzed the interrelationships among characteristics of the teaching machines, characteristics of the programs they present, and characteristics of the learners who use them. They have also explored the possible effect on learning these interrelationships might have. These discussions have been based on a small but steadily growing body of research on programmed teaching-machine instruction, a summary of which appears in two recent source books (5 & 19). Recent summaries of the considerable amount of instructional film research on active student participation, one of the key features of programmed instruction, are also available (1&16). Research on the application of auto-instructional programming concepts to television instruction, in contrast, has just begun. Little solid evidence is as yet available on specific parameters of television presentation which might influence its capability of offering programmed instruction. The purpose of this report is to explore some of the issues involved in programming learning sequences for television. The report will draw on relevant discussion and evidence from research described in this series of studies, from teaching-machine research, and from instructional film research.

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BASIC OBJECTIVES AND FUNCTIONS OF PROGRAMMED AUTO-INSTRUCTION

Before evaluating the functional capability of the television medium to present programmed instruction, it would be useful to review briefly some basic characteristics of programmed instruction with auto-instructional devices. As delineated by those who have pioneered programming for auto-instructional devices (23 & 24), there are two interrelated objectives to programmed instruction including: (a) the control of the conditions under which learning takes place and (b) the accommodation of individual differences in student ability to learn.

Control of learning conditions

Automated, programmed instruction creates the opportunity for precise and systematic manipulation of the variables which influence the effectiveness of student learning. Specific student responses are brought under the control of specific stimuli by leading the student to emit desired responses in appropriate contexts and by appropriate contingencies of differential reinforcement. Through subtle manipulation of these factors and through a process of successive approximations, specific responses can also be developed into complex behavior repertoires (6, 10, & 23). Whether simple or complex, the behaviors to be acquired are, in the idealized situation, under the strict control of the programmer, his program, and the device or medium he selects for displaying the program.

Stated somewhat more concretely, the programmer may develop verbal or pictorial cues to evoke specific verbal responses from students. Either visually (or orally as might be the case in language instruction) he provides students with cues that are adequate to evoke these desired responses. He follows student response as closely as possible with suitable reinforcement. From first to last, he attempts to control the stimulus-response-reinforcement conditions affecting student acquisition of knowledge. His control thus consists of the manipulation of "learning" variables.

The control of student behavior is also brought about through the manipulation of what are often called "motivation" variables. These are the variables that influence the student's persistence in "staying with" the job or task of learning. The student may stay with the teaching-machine "program" and continue to

make responses if the material itself is made sufficiently interesting to acquire reinforcing properties. The preparation of learning sequences that serve to prearrange a high probability that students will respond correctly also serves to insure that reinforcement will follow correct responding frequently. The schedule of reinforcement, in addition to strengthening the acquisition of specific responses, may also strengthen the behavior described above as "staying with" the learning task.

Self-instructional devices presenting programmed instruction thus make possible the two-fold control of student behavior. They provide for the precise and systematic control of the acquisition of stimulus-response connections which operationally defines learning. They also provide for the somewhat less precise and systematic, though appreciable, control of persistent responding which, operationally, may be taken as evidence of "motiviation to learn" Both types of control are necessary for efficient and effective instruction.

Accommodation of individual differences

Another characteristic of the auto-instructional approach which contributes to the efficiency of instruction is the fact that an individual student learns from a program presented in an individual device (of whatever type). Typically, this one-to-one interaction between individual student and individual device has meant that the student could progress through a series of problems at a pace he himself selects. The able student can select a rapid pace, the less able student a slower pace more in keeping with his own ability. This provision for a self-selected pace makes for a high probability that the response the student makes will be correct. Allowing students to proceed through a program at their own pace is, therefore, another technique in the programmer's repertoire of insuring correctness of student responses, resulting in an efficient course of learning. Learning efficiency is also promoted by gearing the difficulty level of a program so that individual differences in student ability can be accommodated. Adaptation to individual differences can be carried still further by "branching" programs in which the sequence as well as the pace of instruction is varied in accordance with the needs of the learner.

By providing each student with his own teaching machine, the control of learning conditions is made systematic and precise for each student. Each student is confronted with a specific visual (or auditory) stimulus in the presence of which he is encouraged to make a particular response. The careful preparation of stimulus materials and the provision for student opportunity to pace himself create appropriate conditions which make the correct, particular response highly probable. The response, when made, is promptly and consistently confirmed or reinforced by informing the student whether he is right or wrong. With the individual student proceeding through an entire lesson unit in this fashion, optimal control over all the stimulus-response connections he acquires is possible.

This is in sharp contrast to the usual classroom situation in which instruction is provided for large groups of students (23). Here the teacher can not typically allow all students to respond frequently, nor does he methodically prepare students to be able to respond correctly. Overt student responding in the classroom is apt to be, at best, sporadic. Teacher confirmation or reinforcement, moreover, is not apt to follow responses consistently or promptly. The use of an auto-instructional device is an attempt to provide an individual "tutor" for each student in order to avoid this unsystematic control by the classroom teacher over conditions under which the student learns. Auto-instructional devices have been designed in an attempt to attain optimal control over as many of the conditions under which learning takes place as possible.

OBJECTIVES IN APPLYING "PROGRAMMING" PROCEDURES TO TELEVISION

There appear to be three key advantages in using television as an educational medium. First, with the transmission of a single lesson, television can provide instruction for hundreds or thousands of students at the same time. The modest cost of lesson preparation (prorated over large numbers of students) and lowered quantitative needs for teachers, both contribute to economy in providing mass education to a growing population. Second, televised instruction, particularly when lesson content is recorded on tape or on film, can be standardized both geographically (across city and even state boundaries) and temporally (potentially over a span of years). The quality built into the lesson content can, as a result, be shared widely. Third, television possesses a highly flexible audio-visual capability which enables a TV instructor to use highly vivid auditory and visual displays in making his presentation. His ability to show close-ups, to show motion, and to show ongoing processes are particularly valuable for those fields which are best taught with the aid of demonstrations.

The logistic efficiency of television is unquestioned. But, pedagogically, how efficient is television or, more appropriately, how efficient <u>can</u> it be? When television, even with its unusual audio-visual capability, employs the conventional lecture method, there is little reason to expect that it will be any more pedagogically efficient than classroom instruction presented in the same way. The incompleteness of teacher control over learning conditions that is found in the classroom, also is likely to occur in more extreme form in the use of television. As already noted in an earlier report (7) and by others, the disadvantages of the conventional lecture method are exaggerated when it is used on television. Due to the physical separation of studio and classroom, the interaction of teacher and students which permits some measure of control over student learning behavior in the classroom is generally not possible in televised instruction. The purpose of several experiments reported earlier in this series has been to develop procedures to overcome this drawback and to evaluate the possibility of <u>building into</u> TV lessons some of the elements of instructional control that characterize <u>programmed auto-instruction</u>. This has included special attention to the sequencing of steps in the program, the encouragement of active, appropriate responding by

all students to the instructional sequences, and the provision of prompt confirmation or reinforcement. What has resulted might be called programmed group-instruction, as distinguished from the conventional TV lecture.

Results reported in an earlier volume (7) provide general support for the relative superiority of programmed group-instruction over conventional group-instruction (conventional lectures). The pedagogical efficiency of televised instruction, it seems clear, can be increased. With advances in the state of the art of programming for groups, even greater efficiency should be possible. But there are undoubtedly limitations to such increases in efficiency. These are due, on the one hand, to physical properties of the group-instructional device (television) which limit the degree to which control of learning is possible and, on the other hand, to problems created by individual differences in student ability to learn from material presented at a fixed pace for group presentation.

It would appear desirable for the future use of television as an educational medium: (a) to make maximum use of TV's audio-visual capability; (b) to retain the logistic advantage of being able to reach large groups of students at the same time; (c) to build elements of systematic control into the instructional situation; and (d) to devise procedures that will, despite group presentation, to an appreciable degree, accommodate individual differences in ability to learn. The answer to whether such a future is possible will depend on detailed consideration of characteristics of the television medium, of the kind of programmed lessons it can present, of the administrative arrangements needed for using the programmed TV lessons, and of students who are to be instructed.

PHYSICAL CHARACTERISTICS OF THE TELEVISION MEDIUM

Televised lessons proceed at a fixed pace. Their rate of presentation is built into them and, of course, they proceed independently of what students do. This inherently fixed rate of presentation affects display, response, and confirmation functions related to programmed television instruction. It also affects greatly the capability of the television medium to accommodate individual differences in student ability.

Display functions

Television has the capability of physically controlling the presentation of either visual or auditory stimuli in much the same way that auto-instructional devices can. The amount and kind of visual and auditory material presented in a physical frame or in a unit of time can be closely controlled. Only the material judged to have the necessary and sufficient cue-strength to elicit a desired response need be presented. The fixed duration selected for displaying particular stimuli may, however, influence their cue-strength or, in other words, their ability to elicit appropriate or correct responses. In teaching-machine instruction with unlimited time allowed by a variable and student-selected display duration, all or nearly all students may be adequately prepared to make a particular response. In the case of television instruction, on the other hand, with limited time allowed by an invariable and teacher-selected display duration, the same stimulus display may inadequately prepare some students to respond correctly.

In auto-instruction, individual differences in ability to respond correctly are accommodated even though the same cues are uniformly presented to all students. The self-selected, variable duration of stimulus presentation provides for accommodation of individual differences. In group instruction, on the other hand, individual differences are, instead, doubly neglected by coupling uniform cues with a uniform duration of presentation. Unless the uniform duration is selected to accommodate the slowest student in the group, high error frequency in student responding is likely to result. Although the selection of a duration long enough to accommodate the slowest student may serve the aim of providing acceptable instruction to all students in a large group, it may lead to highly inefficient instruction for students of better than average ability.

However, the highly flexible audio-visual capability of the television medium exceeds that of most current teaching machines. Printed or oral verbal cues, static pictorial cues, and live or animated cues of motion or process can all be used on television. Television can present or display all these cue forms in the controlled way required for programmed instruction. What it cannot do efficiently in a single program source presented to all students is to allow for individual differences in student ability to "take in" the display. This is primarily due to fixed rates of presentation.

Response functions

In auto-instructional programs, the stimulus display commonly includes a blank to be filled in by the student. The time allotted for reading the stimulus materials and the time allotted for responding by filling in the blank constitutes a single unit of time. The student can not only take as long as he needs to read the material but also can take as long as he needs to be able to respond appropriately. When programmed televised instruction consists of printed visual displays, a single unit of time may be allotted both for reading the lesson materials and for filling in blanks (if the blank is on the screen at the same time). If, however, the TV lesson material is presented orally, the stimulus is presented in one unit of time, and when that time is up, the opportunity to respond is then provided in a separate unit of time. Response as well as display functions are, therefore, influenced by the fixed pace of television presentation. The uniform amount of time allotted all students to respond to lesson materials is, again, in marked contrast to the variable amount of time allowed in the use of an auto-instructional device. These differences in amount of time allowed for responding undoubtedly influence the probabilities that responses made will be correct. If students are allowed shorter durations for responses than those which are empirically established as being minimally desirable, high error frequencies, particularly for students of average or below average ability, are likely to result.

Auto-instructional devices and television (as a group-instructional device) also differ in provisions each makes for recording student responses. In the case of auto-instructional devices, mechanisms for recording responses are integral parts of the device. They may, depending on the particular device, include facilities for a written response (or an oral response in the case of language instruction) or for the selection of a multiple-choice option. In either case, the mechanism

to record responses is a key part of the device itself. The "program" advances in some devices only after a student has responded.

In the case of television, student responses can be recorded with procedures, materials, or devices that are in the nature of adjuncts to the television receiver. One possibility is the use of complex equipment systems to record multiple-choice responding (2 & 12). Another possibility is the use of various paper-and-pencil arrangements to record constructed written responses or multiple-choice responses. A variety of such mechanical or procedural arrangements are possible. But, the television program, unlike the auto-instructional program, will advance no matter what any individual student may do.

In programmed television instruction, it is also possible to encourage students to "say" answers to themselves (covert response) or to say them out loud. Neither overt nor covert responding has generally been shown in instructional film research to be consistently superior in effectiveness to the other (14 & 22). Although there was no direct comparison of overt and covert oral responding in the present study, both these forms of active responding were used effectively. Their chief advantage over written responding lies in the economy in time they make possible, since either form of oral responding takes less time than responding in writing and more material can, therefore, be covered per unit of time.

Efficiency, as measured by the amount of material covered and learned per unit of time, is an important educational objective. Although oral responding makes for efficiency in time, it does have the disadvantage of providing for less control over student behavior. The teacher in the classroom cannot observe whether or not a given student is complying with instructions to respond. Techniques may be built into a television lesson which are designed to encourage active responding but, unless there is a record of such responding, there is no way to know whether or not it has actually occurred. In future routine use of programmed instruction (both for TV and for auto-instructional devices), a trade-off may be required between the degree of control (made possible by written responses) and the degree of efficiency (made possible by covert or overt oral responses) that is to be achieved. It seems not unlikely that a judicious mixture of the two might afford the best solution.

There are other advantages to a record of performance in addition to its providing a tangible index of student response. Over and above indicating whether a student has responded, the record also indicates whether the student has responded correctly. During the development of a program, this kind of feedback to the programmer is essential. In the subsequent instructional situation, this kind of feedback may also be important to the teacher as a basis for providing counseling to students following telecasts. An analysis of errors can be used to provide individual or classroom guidance and correction (in addition to the correction provided by feedback to students in the form of information built into the lesson itself). Classroom correction may be a necessary adjunct to programmed group-instruction to accommodate individual differences and can be provided effectively only if a record of performance is available.

Efforts to motivate students to attend to the televised lesson and to respond at designated, appropriate times during the lesson, can also be aided by having a record of performance. Student attention to the lesson may be increased by providing reinforcement for individual responses and by providing reinforcement only when workforms are completed. Increased attention to the televised presentation may also result from immediate reinforcement of responses. Reinforcement for attention to the lesson may serve to overcome competing attractions or distractions in the classroom.

In summary, it can be said, that a considerable measure of control over student responding is possible in programmed television instruction. Control may be derived through the use of adjuncts to the televised presentations which can succeed in eliciting responses throughout the course of a lesson. While programmed television instruction can be made more efficient than conventional TV instruction by requiring such student rehearsal of responses during the course of a lesson, the inability to accommodate individual differences effectively must inevitably place a ceiling on the degree of improvement possible.

Confirmation functions

Auto-instructional devices are designed to provide knowledge of results to students in a variety of ways. The purposes for such an arrangement have been identified to be: (a) the correction of wrong student responses or (b) the confirmation of correct responses, with such confirmation interpreted as being

reinforcing if the learner's motivation is intrinsic to the task being learned (4). The nature of feedback to the student can vary depending on differences in physical mechanisms characteristic of various auto-instructional devices. There are variations with respect to the following dimensions: (a) kind of information provided (students may be provided with the correct answer, and they then can compare their answer with the correct ones or they may be told that their answer was correct); (b) the temporal delay in receiving confirmation (confirmation may be provided only after the student responds correctly or after any response is made, whether correct or not); (c) number of response opportunities (the student may be allowed several trials until he responds correctly or he may be allowed only one trial, whether correct or not); and (d) amount of response prompting (incorrect responses may be followed by additional prompts to facilitate correct responses). These variations in confirmation functions provided by various auto-instructional devices have been reviewed elsewhere (3 & 13).

The practical effect of these variations and their interactions on learning still remain a subject for further research. In most instances, however, the confirmation or feedback function is fulfilled in automated, auto-instruction at a pace determined by the learner. He need not go on to the next frame or unit of instruction (in most arrangements) until he is ready to do so. Confirmation provided in programmed television instruction is, as in the case of display and response function, influenced by the fixed rate of presentation. Since the TV presentation progresses independently of student responding, the amount of time allotted to confirmation or feedback is uniform and invariable for all students. The opportunity adequately to compare one's own constructed response with the correct response provided orally by the instructor or visually on the screen may, for some students, be reduced. There may be difficulty under pressure of time to decide how well one's own response matches that provided in the lesson. This may be particularly true in an oral presentation in which, once a statement is made by the instructor, it is available only in memory for comparison with one's own response. The degree of effectiveness of the confirmation function may be affected as a result.

The television medium is capable of providing confirmation (reinforcement) in ways similar to auto-instructional devices. But, in televised presentations, whatever information is used to provide confirmation will follow student opportunities to respond whether or not students have responded and whether or not students

have responded correctly; confirmation may also tend to follow without allowing students sufficient time to rehearse a correct response following correction. What effects these conditions will have on learning will, as in the case of instruction with auto-instructional devices, have to be investigated in future research. While television can provide confirmation and can, with some measure of flexibility, control its presentation, television does not have the capability of making adequate accommodation of individual differences.

Functional capability of the television medium

On balance, the physical properties of the television medium appear to provide it with the functional capability of offering programmed instruction. With the aid of collateral procedures or equipment systems to record responses, television can provide physical control over display, response, and confirmation functions essential to programmed instruction, thus exercising control over the relevant conditions under which stimulus-response connections are acquired. This can be accomplished, in the first instance, by precise control over the stimulus presentation. It is possible to control the amount of lesson material presented in a physical frame. Control is also possible over the duration of its presentation prior to the opportunity given the student to respond. After the student is systematically given the opportunity to respond, confirmation can be made to follow promptly. The amount of time allotted for responding and the timing of confirmation (how soon after the opportunity for responding it occurs) can also be controlled.

Further control over the precise stimulus-response connections students are expected to acquire can be achieved by careful preparation of lesson materials, by rehearsing and pre-testing lessons, by revising lessons on the basis of pre-tests, and by recording lessons. These techniques can serve to preclude the adventitious inclusion of non-relevant stimulus materials and to preclude stimulus materials that are likely to fail to elicit the desired student responses.

Control over student motivation to learn is also possible. Reinforcements intrinsic to the presentation, in the form of arresting materials, and reinforcements extrinsic to and contingent on the collateral procedures employed to record responses, can insure persistence of student responding. The dual control over learning and motivational conditions can contribute to potentially upgraded television instruction. Whatever limitations there are on that potential are primarily

imposed by the apparent inability of the television medium to accommodate individual differences in student ability. While the over-all effectiveness of televised instruction can be increased by programming procedures, special efforts will be needed to solve the individual difference problem. The solution to this problem would seem to lie in variations in the programmed materials presented to students.

ROLE OF THE "PROGRAM" USED WITH INSTRUCTIONAL DEVICES

The physical configurations of auto-instructional devices (teaching machines) are utilized in programmed instruction primarily to provide mechanical and systematic control over the conditions under which learning takes place. Physical properties of the devices provide for three-fold control: (a) mechanical control over the quantity and duration of stimulus presentation; (b) mechanical control over the duration of the opportunity provided students to make a response; and (c) mechanical control over the timing and duration of confirmation or reinforcement that follows the response.

The conditions under which students acquire stimulus-response connections are thus under the control of the device. The specific stimulus-response connections they acquire are under the control of the programmer and the program he prepares for use in an auto-instructional device. The type of control afforded by particular devices, as described in earlier sections of this report, will, in interaction with the program presented, influence the programmer's success in bringing about the objectives of his program.

Program objectives

The ultimate objective of a program as described in the literature on auto-instructional devices, may be to put into the behavioral repertoire of students those responses that define what we mean as knowledge of facts, understanding of concepts, perceptual-motor skills, or other prescribed terminal achievements. The sought-after outcome of the program is student ability to make appropriate and correct responses to such stimuli as the following: "what is the formula for computing the area of a circle?", "what is the French word for 'mushroom'?", "give an account in terms of molecular activity of how heat affects solids", or "throw the ball as closely to the bullseye as you can." At the conclusion of a program designed to teach students responses to these questions or problem tasks, the correct responses which eventually enter students' behavior repertoire are obviously different in kind and in complexity from the ones they began with. The gap between initial and terminal repertoires may, indeed, be quite large. The strategy of programming designates the objective of bridging that gap.

The tactics for bridging the gap from behaviors already in the possession of the student to those we wish him to acquire call for a series of intermediate successes. Programs are built on what is already known so that the student is enabled to make a response that is relatively simple and relatively easy. Each new response to be made goes only slightly beyond what the student already knows. With suitable crutches, the student is aided to proceed gradually from one response to the next until he possesses all the new responses he needs to provide a complex, final answer. To illustrate, in teaching students how heat affects solids, the student might first be taught what a molecule is, then, what the nature of molecular activity is, then, how heat affects molecular activity, and finally, how the size of objects and molecular activity are related.

Throughout the program, the programmer strives to insure correct student responding which he can then follow promptly with reinforcement. Correct responding followed by reinforcement at each stage builds up the mastery (of fact or concept) necessary to go on to the next, perhaps, slightly more complex stage until finally the student is brought up to the level of mastery that was the primary goal of the program. With the aid of the crutches and supports that insured his successful traversal (correct responding) of early stages, he is brought to the point where he is able to explain concepts, to recount facts, or to exercise complex motor skills and is able to do so without the aid of crutches used earlier.

Programming technology

The tactics of programming are designed to insure correct responding at all points in the program. Although programmed instruction with auto-instructional devices is still relatively young and programming, as programmers are eager to confess, is still an art, a considerable programming technology is developing. That technology has been described (11) and reviewed elsewhere (6 & 15). The basic approach to elicit correct student responses at each part in the lesson appear to include the following: (a) reduction of the lesson into small, easily mastered steps; (b) the inclusion within each step of appropriate cues or prompts that are sufficient to elicit the desired response; and (c) the sequencing of steps so that mastery of a given step in addition becomes a cue for the mastery of the next step.

The progression from initial to terminal repertoire is also made possible by the logical sequencing of individual steps. Also, since the desired terminal

behavior often consists of rather complex responses made in the presence of minimal cues, cue strengths within the sequences are gradually diminished. Only a cue-strength that is judged necessary at a given step is aimed for. The ultimate aim, of course, is maximum response strength in the presence of minimally strong cues. For example, the student may be expected to give an account of how heat affects solids without any of the cues which were needed earlier in the program to enable him to make correct responses about the nature of molecules or molecular activity. This is achieved by starting with maximally strong cues and eliciting, at first, minimally strong responses. The shift in cue and response strength comes about through a process of gradual weakening of cues and through gradual increments in response strength.

Program preparation

Preparation of programs proceeds from an initial analysis of the terminal behavior or responses to be acquired to an analysis of the intermediate appropriate responses that must be acquired in order to reach the terminal behavior. The rational arrangement of the sequences of responses to be acquired then follows. Similarly, judgments are made about the cues at each learning stage that will be sufficient to elicit the desired, appropriate responses. The ultimate test of these judgments lies in an empirical test of the program. Programs can and should be thoroughly pre-tested to determine whether students can, in fact, make correct responses at each step in the program. When a sizable percentage of students are unable to respond correctly, the program is revised. Material reductions in error frequencies can be brought about in this fashion particularly when the programs are pre-tested with a sample that is representative of the population ultimately to be taught.

Accommodation of individual differences

In auto-instructional programs in which students proceed from the beginning to the end of a program without any detours, often called a "linear" program, individual differences can be accommodated in two ways. First, assumptions about the prior preparation of the students to be taught may be made. Judgments about the responses already in their behavioral repertoire that can be classed as generalized abilities are made. Similarly, judgments about responses in their behavioral repertoire more directly related to the subject matter to be taught are also made.

Assuming variation in prior preparation levels of the students he seeks to instruct, the programmer may then decide to gear his program to the lowest level in his population. In so doing, he may be able to accommodate all or nearly all students as measured by learning effectiveness (i.e., low frequencies of student errors committed during the program). As measured by efficiency in time, he may with this approach require above average students to spend more time than necessary on the same material. He may also be diminishing their motivation to learn by subjecting them to presentations that for them are overly repetitious and dull. Research on tolerance limits of bright students for this kind of material and presentation still remains to be done.

The programmer may decide to gear his level of presentation to the average student. With such a program, he then relies heavily on the self-pacing capability of the auto-instructional device, the second method of accommodating individual differences. The assumption behind this technique is that, if given sufficient time, all students at even below average ability should be able to produce a correct response to the program prepared with the average student in mind. (Further research may be necessary to test the adequacy of this assumption.)

Still another linear approach is to prepare separate complete programs for students at different ability levels. Bright students or retarded students can be instructed with programs especially geared to their level of ability. This approach corresponds to the separate track approach in public education and may make for greater efficiency in learning. This approach is, aside from economic and logistic constraints, potentially applicable to film and TV instruction.

A third technique involves the use of non-linear programs called "branching" programs to accommodate individual differences. Students making particular responses at a particular step in a program are allowed either to by-pass certain material or are required to cover additional material before being allowed to rejoin the main stream of the program. In the former case, above average students can by-pass material which they may not need to master in order to reach desired terminal responses but which average or below average students might require. In the latter case, below average students who have made errors and have shown themselves unable to master particular points may be required to undergo supplementary or, perhaps, corrective training.

The objectives of the program, like the objectives in the use of the auto-instructional device are two-fold. First, the program insures that specific responses are brought under the control of specific stimuli. It accomplishes this by successfully eliciting responses in the presence of the appropriate stimuli and by providing feedback as to the correctness of response. The control achieved by the program is, thus, over specific stimulus-response connections each student acquires. The second objective of the program is the accommodation of individual differences. This objective is attained by the level of student ability to which it is geared and by such non-linear procedures as branching.

PROGRAMMING FOR TELEVISION

The objectives, the technology, and the methods of preparation of auto-instructional programs appear applicable to the preparation of group-instructional programs. Students can be brought from an initial behavioral repertoire to a final one which is quite unlike it, being larger and/or much more complex. Lesson materials can be reduced into small steps, sufficient cues seeded within steps, and steps themselves sequenced so that correct responses can be elicited. Program goals can be identified, the intermediate steps to attain them developed, and the whole program pre-tested to evaluate its adequacy. In all these respects, programming for auto-instructional and for group-instructional presentation appears quite similar.

Three key differences in the two types of presentation would appear to require differences in the details of the actual programs. These differences include: (a) televised instruction proceeds at a fixed rate of presentation; (b) it is prepared for presentation at the same time to students in groups; and (c) televised instruction is most often orally presented. Each of these factors alone and in interaction with one another does put some constraints on the kinds of programs that can be written for television. Of primary concern is whether these factors will permit the development of programs which will produce for individual students acceptable rates of correct responding.

The program attempts to foster high levels of correct responding. When the same program is prepared for all students, the cues within sequences and the sequences themselves, may be inadequate to elicit correct responses from all students. Moreover, the pressure of time created by the fixed duration for display, response, and confirmation functions that is selected and imposed on all students may lead to a high frequency of student errors. Further, when material is presented orally, the difficulty level of the material, as measured by the probability of committing an error, may be increased. Stimulus materials presented visually, printed words for example, remain on the television screen for a period of time. Even though the duration allotted for its exposure may be uniform for and hence inadequate for all students, it nevertheless remains on the screen as a directly available stimulus. In an oral presentation, the same material, once

presented, remains available only in the form of memory cues. The cue-value (that is, the ability to elicit a correct or appropriate response) of the same verbal material may differ when presented in these two different ways. An oral presentation of lesson materials that are uniform for all students and presented at a uniform, fixed rate for all, would appear to make minimal allowance for individual differences in student ability.

Further technical and administrative procedures will have to be developed before programmed group-instruction can adequately accommodate individual differences. Evidence presented in an earlier report in this series (7) has shown that efforts to program for groups widely varying in ability may backfire with low ability students being hindered rather than helped by programmed material unless the material adequately prepares them to make correct responses. Further research is needed to discover how better to accommodate individual differences, short of teaching individuals, and still retain the logistical advantages of group-instruction.

Two possible directions for correcting this deficiency are: (a) the preparation of a program geared to the lowest common denominator or (b) the preparation of separate programs for different, relatively homogeneous groups. In the first case, the program would be prepared in such a way as to permit the least able students to respond correctly with high frequency throughout the course of the presentation. Preparation of students to be able to do this would consist of conventional programming procedures. Combined with the preparation of programmed materials would be the selection of durations for stimulus display, response opportunity, and for feedback of results that would allow for correct responding.

The second approach would call for the reduction of an entire viewing audience into homogeneous sub-groups. The most efficient number of sub-groups in terms of measured terminal achievement and in cost terms remains an empirical problem. The approach would attempt to program material varying instructional parameters such as step size or amount of repetition and review appropriate for each sub-group. Similarly, the approach would attempt to allow time intervals for display, response, and confirmation functions that are appropriate for each sub-group. (Gearing the level of presentation to the lowest level in a homogeneous sub-group would appear to be capable of eliciting correct responding in all members of the sub-group without penalizing those at the top too severly.)

The advantages of the "lowest common denominator" approach for single track (total group) instruction would be its economy in cost. Its potential disadvantages would be loss of efficiency (amount of material taught) for above average students and also the possible loss of student interest. The advantages and disadvantages of the "homogeneous sub-group" approach are the converse of the first approach. Its primary disadvantage lies in the cost of preparation and transmission of separate instructional tracks. Its primary advantage would lie in efficient instruction, ideally teaching students as much, per unit of time, as they can absorb. Any eventual trade-off between cost and quantitative and qualitative learning efficiency must be an administrative decision. In making such decisions, it should be borne in mind once again that when costs are prorated over large numbers of students and over a number of years, the per-student cost may not be considered too high. Any index of instructional efficiency should ideally consider the amount and quality of instruction attained per unit of time for each student along with its cost.

The remainder of this section will be devoted to specific procedures and problems in programming for television and will, in part, be based on the practical experience gained in the studies reported in this series representing initial attempts to program for fixed-pace group presentation. Particular attention will be paid to oral presentations and the problems they raise since the general discussion above would appear to apply to and adequately cover visual presentation of printed material.

Size of step

One of the main principles in programming learning sequences calls for the reduction of lessons into small segments or steps. Programmers would agree that the purpose of such a reduction is to make the material more easily mastered. Differences of opinion do exist, however, as to what is meant by the size of a step (17). Some define it in terms of independent variables under the control of the programmer, for example, the amount of stimulus material presented before a response is required. Others define it in terms of dependent variables such as the size or complexity of the required response or the difficulty of making such a response.

Whatever the definition of step size, it would appear that in televised instruction the need for small steps is, perhaps, even more urgent. The urgency derives from the pressure imposed on the learner by the fixed pace of the television lesson and by the necessity to rely heavily on memory cues for responding during an oral presentation. Both these variables may strongly influence student ability to master a step. Because of this possible influence, it is probable that the same material prepared for presentation in an individual teaching machine or for presentation on television would unequally prepare students to respond correctly. In the case of televised presentation, the same material would, perhaps, better prepare students to respond correctly if reduced to even smaller steps. This would seem to be particularly true in oral presentations in which the material, once presented, is no longer directly available as a stimulus. Large amounts of material available only in the form of memory cues may fail to elicit desired responses. Defined as an independent variable, that is, the amount of lesson material presented before requiring a response, the size of the step may have to be unusually small. On the other hand, the amount of stimulus material may possibly be allowed to be large if the cue value of the material is made unusually strong. Since strength of cue-value derives from the use of words and concepts with which students are highly familiar and from frequent repetition, the program prepared for oral presentation will be most likly characterized by these variables.

Cueing

Cues in programmed instruction serve two purposes: (a) to elicit responses per se; and (b) to elicit specific responses. In auto-instruction with teaching machines, instructions about responding and underlined blanks (to be completed) serve as cues for responding. Instructions to students in programmed television lessons can serve that same purpose, and, if printed material is visually presented, blanks can also serve as cues. When the presentation is oral, cues as to when to respond may consist of lecturer pauses and at times a rising inflection toward the end of phrases or sentences. In many instances, however, phrases do not lend themselves to a rising inflection. In the studies reported in this series, one technique used to heighten the cue to respond was the flashing of a question mark on the screen to accompany the pause by the lecturer (see Figure 1).

Figure 1

Other visual and/or auditory accompaniments should be able to serve the same purpose. Still other techniques are possible. For example, during the pause, the instructor might occasionally remind students to make a response -- "say the answer to yourself" or "write the answer on your worksheet." His comments can be more directly related to the prior cues or prompts and serve both as a prompt for responding and also as a cue or prompt for a particular response. For example, he might say, "how big a force," "what kind of force," or other similar more direct, substantive prompts.

Other collateral techniques may also be employed. Perhaps the most potent, as discussed earlier, would be an accompanying workform with blank spaces to be filled in by the student. The set to respond may further be stimulated by instructions that urge the student to compete with the instructor ("say the answer before I do"). Having other students shouting answers out loud may also serve to stimulate responding (although this procedure might possibly interfere with the confirmation or feedback function). A variety of techniques do appear capable of encouraging students to respond. Their role, as the role of other variables, requires further research in this new area of programmed group-instruction.

A perhaps more crucial area for investigation is that of the techniques for cueing or prompting the specific responses to be elicited. It is reasonable to suppose that the thematic and formal prompting techniques applicable to auto-instruction can be transferred to televised group-instruction. This is, of course, an empirical problem. Evidence from the present series of studies suggests that

many of the conventional programming techniques can be applied to television. It can be said, however, that the various issues which still remain open in the case of auto-instruction and which have been described elsewhere (17 & 18) will also require resolution here.

The fixed pace of televised instruction, its use of oral presentations, and its objective of accommodating a group audience may superimpose additional problems on those that already exist for auto-instruction. Thus, separate research on these issues, it would appear, will probably be required both under the conditions applying in auto-instruction and in group-instruction. One problem that suggests itself is concerned with the pre-testing of programs for TV presentation. In preparing a verbal, connected-discourse program, it may be relatively easy to make judgments about the adequacy of a program that will be read by students (either in a teaching machine or on TV) by reading the program oneself. When the material is to be presented orally, reading the program through to evaluate its adequacy may be insufficient. The primary difference lies in the direct availability of stimulus cues in reading but their indirect availability in the oral presentations. Pre-testing would appear under these circumstances to be even more necessary. Pre-testing would naturally have to be done with an <u>oral</u> presentation under the fixed-pace conditions that would prevail ultimately in the instructional situation.

Despite the limitations that are imposed by factors that distinctively characterize television presentations, there are several assets to such presentations. These assets may serve to facilitate the cueing function. Even though televised instruction may be presented orally, it is still possible to use visual cues as accompaniments. The dual use of visual and auditory cues may provide for unusual flexibility in cueing. Visual cues can be particularly useful in science instruction, for example, where demonstrations play a large role. Television has the flexible capability of presenting motion and process as well as static pictures. The cue for particular responses can be objects that the instructor is pointing to. (See Figure 2 for a model of a television receiving tube. Here the instructor can point to the grids that attract the electron beam either from side to side or to each successive line from the top to the bottom of the screen.)

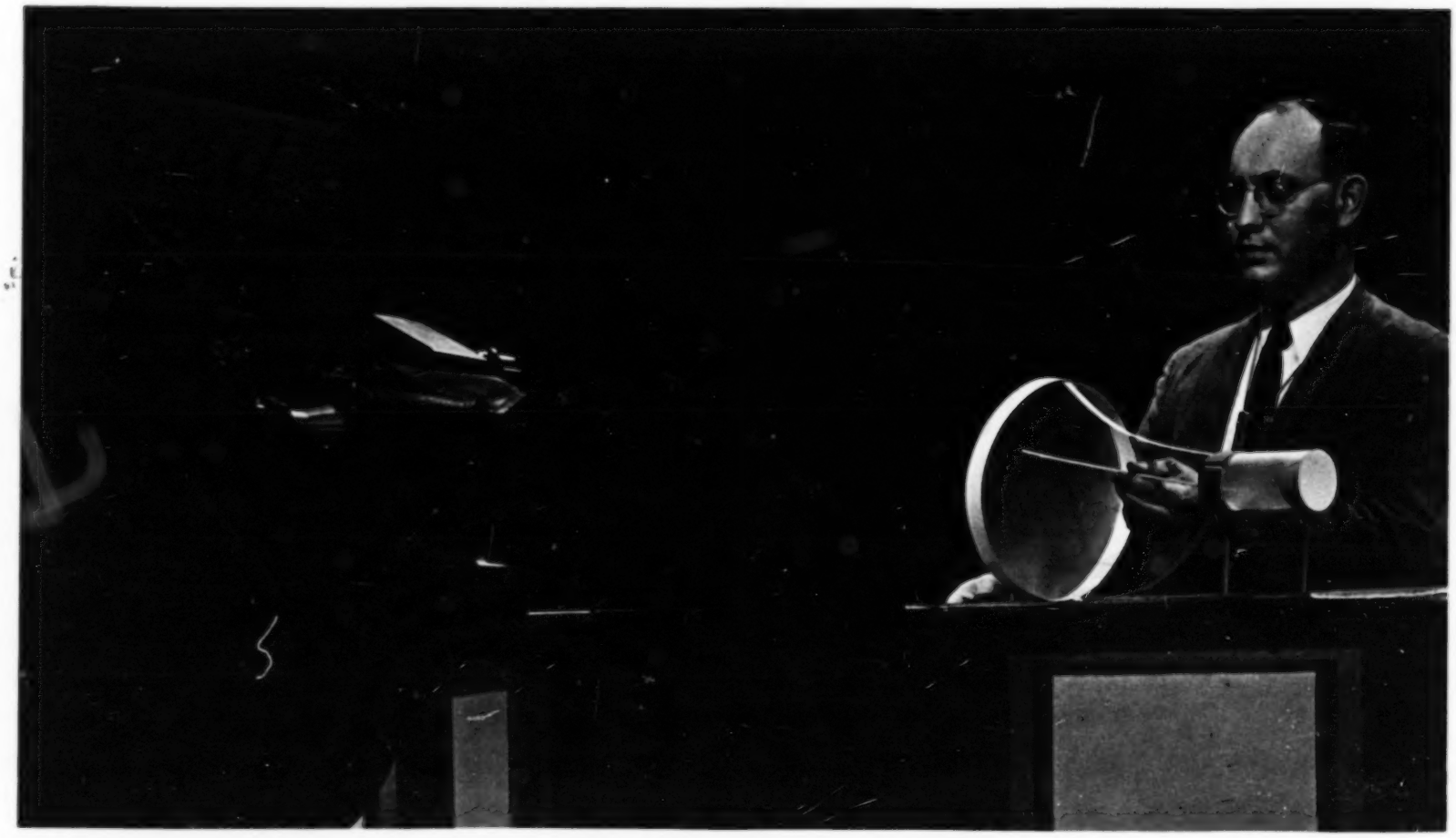

Figure 2

The instructor can also point out ongoing processes. Examples of the latter that suggest themselves are water rising in a tube when heated, the bending of a bi-metal bar, animated representation of molecular activity, etc. These events should prove to be effective cues for such verbal responses as: "rises," "bends," or "move fast." Thus, while the burden of programmed instruction may be carried by the oral presentation, the cueing of particular responses can be bolstered by visual stimuli. Moreover, the visual representation may contribute to more effective learning and understanding than is, perhaps, possible solely using verbal stimuli. Demonstrations, of course, are used to illustrate verbal principles, and considerable research still remains to be done to determine how best to integrate visual and oral presentations. Evidence from Report No. 1 (7) in this series has shown how difficult it often is for students to grasp the principle being illustrated in a demonstration.

Not only may the telecast of ongoing demonstrations accompanying an oral presentation be useful in eliciting student verbal responses, they may also be useful in eliciting the motor responses involved in the performance of science experiments.

In one of the lessons prepared for one of the studies in this series (8), students in the classroom were encouraged to match a lever-fulcrum-load situation they saw on the screen. With the fulcrum at varying distances from the load, students were instructed to push down at the other end of the lever to discover the variations in force needed as a function of the varying distances of the fulcrum from the load. This is an illustration of how ongoing events on the TV screen can be used to stimulate particular motor and verbal responses. Other such possibilities can and should be explored to facilitate efficient and effective learning.

Response terms

Experience in programming learning sequences for television lessons used in this series of studies has raised some practical considerations about responses to be elicited by a program. In auto-instructional programs, blanks to be filled in may appear at the beginning, the middle, or the end of the physical segment (called a frame) which is the unit presented to the student at any one time. If learning sequences are presented on television in printed form, the same possibilities apply. If they are presented orally, on the other hand, pauses (rather than blanks) must come at the end of phrases or sentences that contain complete ideas or thoughts. Otherwise, the statements will probably be inadequate to elicit correct responses. In only limited situations would it appear that statements would have sufficient cue-value to permit additional material to follow a pause (with the student then expected to go back and fill in the blank when the entire statement or sentence is completed).

Further, it is not likely that in oral presentations that more than one completion within a single sentence or statement can effectively be made. This puts some constraints on the type of sentences that can be written, the type of grammatical content possible, and the response terms that can be expected. These are some of the building blocks of programming and if unavailable, would represent limitations on programming possibilities. The impact on program effectiveness would be serious if key response terms could not be made because of these constraints. It might be that in those situations in which verbal constructions if presented orally would be awkward, printed frames would be desirable and a possible alternative.

In addition to the timing and frequency of responses that might be made during an oral presentation, there may be limitations on the complexity of response to be

made. During final stages of a program or section of a program, when prompts are withdrawn and when many individual responses have been acquired, it is often desirable to require students to emit complex response sequences. It is particularly at this point that the fixed-durations of televised presentation may make such complex and lengthy responses unfeasible.

Programs for television

In summary, it might be said that programming techniques applicable to auto-instruction with teaching machines should in general be applicable to television. When so transferred from one medium to another, the problems and issues found in the one are very likely transferred to the other. Many issues of "how," "in what way," and "why" pertinent to auto-instruction undoubtedly are pertinent to televised group-instruction. In addition, there appear to be some advantages, some problems, and some practical and theoretical considerations that are superimposed when programmed instruction is presented at a fixed rate, is presented orally, and is presented to groups of students. The research issues outstanding in automated instruction are joined by a host of new ones raised by efforts to program instruction for television.

THE FUTURE ROLE OF PROGRAMMED TELEVISION INSTRUCTION

It is difficult to foretell what role programmed television instruction or even conventional television instruction will play in the future. What portion of the instructional load it will have to share with the classroom teacher, with films, or with teaching machines is difficult to say at this point. The answer will depend on the functional capabilities of each to offer efficient, economical, and quality instruction. Television, when offering programmed instruction, has numerous assets to offer. It is, at present, encumbered by a number of liabilities, but as has been suggested, future research may aid in overcoming many of them.

Conventional TV instruction has the logistic capacity of reaching large numbers of students and when recorded, the same lessons can be repeated in different geographical areas and at different times. In addition, television has an unusually rich and flexible audio-visual capability that can make substantial contributions to instruction in various subject matter areas (its function as an audio-visual aid). It is the same audio-visual capability which enables TV instructors and TV producers to build into televised presentations the elements of instructional control that characterizes programmed instruction. In this latter instance, the audio-visual capability is not used as an aid or adjunct to instruction. It is, rather, used more instrumentally as a means of controlling the conditions under which learning of subject matter occurs.

Television can, as do teaching machines, provide for physical control over stimulus presentation, over the opportunity to respond, and over the occasion for providing feedback to the student. Control over stimulus-response-reinforcement interactions is thus possible. Moreover, with the aid of collateral procedures, such as the use of workforms, control over motivation is also possible. The "programs" that television can present are, to a large extent, the same kind of "programs" that teaching machines present. The rules and technology for programming subject matter for the two media are largely the same, and, these both can control the <u>specific</u> stimulus-response connections that are acquired.

What television cannot do with single track instruction is adequately and efficiently to accommodate individual differences in student ability to learn. This television cannot do (a) because it proceeds at a fixed rate and (b) because it relies heavily on oral presentations. Uniform materials presented at uniform rates to all students who differ from one another in ability precludes student opportunity to reduce these differences by taking one's time in order to be better able to respond correctly. Complicating this condition is the fact that in oral presentations once material is presented it remains only available indirectly in the form of memory cues. This may seriously reduce their cue-value to elicit correct student responses. Reliance on memory cues under pressure of time (fixed durations imposed by televised presentation) can be another serious drawback.

Both the issues of fixed pacing and of the cue-value of memory cues in oral presentations remain for resolution in further research. There is certainly the possibility that for some subject matters and within prescribed limits, pacing of student responses may prove beneficial to learning. Another possibility is that of presenting printed materials (as in teaching machines) on TV save for demonstrations and other visuals in subject matters that require them (demonstrations in science or plays acted out for English, for example). TV or other audio-visual presentations, as pointed out by others (20 & 21), need not necessarily be presented wholly in oral terms. Further research on what might be a judicious blend of oral and visual presentation is indicated.

As to the general problem of accommodating individual differences while instructing students in groups, research on the use of multiple tracks appears desirable. Investigation of the parameters of programmed instruction appropriate to groups homogeneous in ability may provide for both logistic and pedagogical efficiency. For example, it might be possible to vary the parameter of the number of repetitions or the size of step in such a way that sub-groups would most efficiently and effectively be taught. What the appropriate number of sub-groups would be is also a matter for future research. Obviously, a trade-off between learning efficiency and cost efficiency will have to be made. However, it is conceivable that grouping students by ability levels rather than by arbitrary grade levels and providing appropriate instruction for these groups may reduce the cost required to provide instruction appropriate to sub-groups. In this instance, separate homogeneous tracks for ability groups would be substituted for the separate

tracks now made available to different school grades.

Future research is indicated that will tackle both the logistic and pedagogical problems of educational television. Solutions to these problems, it would appear, would make TV a leading educational resource. Along with other media, such as films, teaching machines, or the classroom teacher, it could share the instructional burden created by a large and increasing school population.

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